APPLICATION UNDER UNITED STATES PATENT LAWS

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Invention: CHARGING OF SUBSCRIBERS WITH LOCALISED SERVICE AREAS IN A MOBILE
                TELECOMMUNICATIONS NETWORK

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☐ Provisional Application

☐ Regular Utility Application

☐ Continuing Application
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    by reference

☒ PCT National Phase Application

☐ Design Application

☐ Reissue Application

☐ Plant Application

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SPECIFICATION

Charging of subscribers with localised service areas in a mobile telecommunications network

Background of the invention

The invention relates to equipment and a procedure for supporting charging of subscribers with localised service areas in a mobile telecommunications network which comprises a packet radio network. An example of such networks is a combined GSM/GPRS network.

Fig. 1 is a block diagram illustrating a cellular telecommunications network supporting circuit-switched (CS) connections (e.g. Global System for Mobile Communication, GSM) and packet-switched (PS) connections (e.g. General Packet Radio Service GPRS). Circuit-switched connections are shown as solid lines and packet-switched connections are shown as dotted lines. The basic structure of the GSM system comprises two elements: a base station system BSS and a network subsystem NSS. The BSS and mobile stations MS communicate over radio links. In the base station system BSS each cell is served by a base station BTS. A number of base stations are connected to a base station controller BSC, which controls the radio frequencies and channels used by the BTS. Base station controllers BSC are connected to a mobile services switching centre MSC. As regards a more detailed description of the GSM system, reference is made to the ETSI/GSM recommendations and *The GSM System for Mobile Communications*, M. Mouly and M. Pautet, Palaiseau, France, 1992, ISBN:2-957190-07-7.

The GPRS infrastructure comprises support nodes such as a GPRS gateway support node (GGSN) and a GPRS serving support node (SGSN). The main functions of the GGSN nodes involve interaction with the external data network. The GGSN updates the location directory using routing information supplied by the SGSNs about an MS's path and routes the external data network protocol packet encapsulated over the GPRS backbone to the SGSN currently serving the MS. It also decapsulates and forwards external data network packets to the appropriate data network and handles the billing of data traffic.

The main functions of the SGSN are to detect new GPRS mobile stations in its service area, handle the process of registering the new MSs along with the GPRS registers, send/receive data packets to/from the GPRS MS, and keep a record of the location of the MSs inside its service area. The subscription information is stored in a GPRS register (HLR)

where the mapping between a mobile's identity (such as MS-ISDN or IMSI) and the PSPDN address is stored. The GPRS register acts as a database from which the SGSNs can ask whether a new MS in its area is allowed to join the GPRS network.

5   The GPRS gateway support nodes GGSN connect an operator's GPRS network to external systems, such as other operators' GPRS systems, data networks 11, such as an IP network (Internet) or a X.25 network, and service centres. A border gateway BG provides access to an inter-operator GPRS backbone network 12. The GGSN may also be con-
10   nected directly to a private corporate network or a host. The GGSN includes GPRS subscribers' PDP addresses and routing information, i.e. SGSN addresses. Routing information is used for tunnelling protocol data units PDU from data network 11 to the current switching point of the MS, i.e. to the serving SGSN. The functionalities of the SGSN and GGSN can
15   be connected to the same physical node.

The home location register HLR of the GSM network contains GPRS subscriber data and routing information and it maps the subscriber's IMSI into one or more pairs of the PDP type and PDP address. The HLR also maps each PDP type and PDP address pair into a GGSN
20   node. The SGSN has a Gr interface to the HLR (a direct signalling connection or via an internal backbone network 13). The HLR of a roaming MS and its serving SGSN may be in different mobile communication networks.

The intra-operator backbone network 13, which interconnects
25   an operator's SGSN and GGSN equipment can be implemented, for example, by means of a local network, such as an IP network. It should be noted that an operator's GPRS network can also be implemented without the intra-operator backbone network, e.g. by providing all features in one computer.

30   In cellular mobile communications systems, a mobile station may roam freely within the area of the mobile communications network and connect to the base transceiver station signal received best at a given time. Usually, all base transceiver stations provide substantially similar services for the mobile stations in a network. Some base transceiver sta-
35   tions can, however, be defined to provide a certain special service for all mobile stations of the network, e.g. call charges below the normal tariff. The base transceiver station broadcasts a message concerning such a

special service on its packet broadcast control channel (PBCCH), whereby mobile subscribers in the area note that they are within a special service area of the network and may take advantage of this service.

Within the context of this application, such special service areas are referred to as localized service areas (LSA) and the support of LSA is called SoLSA. A subscriber having SoLSA service is called a SoLSA subscriber. A mobile station currently having support for SoLSA is said to be in LSA mode. This may mean e.g. that the mobile station indicates to its user that certain special features (like lower rates or extra services) are available, and it uses these features when applicable. The concept of localised service areas (LSA) is the subject matter of references 1 to 3.

Fig. 1 also shows two LSA areas, LSA1 and LSA2. LSA1 consists of cells C1 to C3, and LSA2 consists of cells C9 and C10. It is assumed that the mobile station MS moves, during a call, along path 10 from cell C1 to cell C10. The call is established in an LSA cell (C1). Between cells C1 and C2, the MS moves slightly out of LSA1, in the sense that better coverage would be obtained from cell C7 which is not an LSA cell. However, the handover algorithm favours LSA cells and, consequently, the MS is not handed over to the base station of C7. When the MS crosses cell C4, the call cannot be maintained as an LSA call. When the MS approaches cell C9, it is handed over to the base station of C9 and the call is again treated as an LSA call.

The present invention involves mainly charging-related aspects of SoLSA subscribers. Charging in a GPRS system is defined in reference 4. For charging, a telecommunications network generally comprises a billing system, such as the Billing Centre BC which may be connected to an MSC, as shown in Fig. 1. The network may also comprise dedicated Charging Gateways CG, as shown between the intra-operator backbone network 13 and the billing centre BC. (Alternatively, the dedicated charging gateways can be replaced by distributed functionality resident in the SGSN and GGSN nodes.)

According to reference 4, collecting charging information in a GPRS system can be briefly summarised as follows. Network elements, such as GPRS support nodes (SGSN and GGSN), monitor charging-related events (transmitting data packets, attaching to the network, mobility management, etc.) The network elements send charging data records, or CDRs, to the Billing Centre BC (possibly via Charging gateways CG).

CDRs created by SGSN or GGSN nodes are called S-CDRs or G-CDR, respectively. In addition, an M-CDR conveys information on mobility management-related charging events. There are also SMO-CDRs and SMT-CDRs for MS-originated and MS-terminated short messages. For each
5   charging-related event, there is a corresponding item or entry in the CDR. In the terminology of reference 4, the charging-related items are collectively referred to as a "List of Traffic Volumes". Reference 4 defines a set of rules for opening and closing each type of CDR, and the contents thereof.

10   A problem with prior art charging systems is that they completely ignore the SoLSA aspects.

Brief description of the invention

        An object of the invention is to provide mechanisms for supporting charging of users with localised service areas in a mobile tele-
15   communications network which comprises a packet radio network. The object is achieved with equipment and a procedure which are characterized by what is disclosed in the attached independent claims. Preferred embodiments of the invention are disclosed in the attached dependent claims.

20   The invention is based on the idea that the packet radio network is adapted to classify the charging-related detail items of the CDR into multiple classes depending on whether or not the corresponding event occurred while the mobile station was in an LSA cell. This means that the mobility support element may actually classify the detail items into two
25   classes, depending on whether or not the corresponding event occurred while the mobile station was in an LSA cell. Classifying the detail items into two classes is sufficient, if the LSA cells are similar as far as charging is concerned. If there are more than two types of charging, for instance more than two different tariffs, then the detail items should classified into a
30   corresponding number of classes.

        According to a preferred embodiment of the invention, a mobility support element, such as an SGSN node or a GGSN node, performs or at least supports this classification. Instead of performing the actual classification, the mobility support element may support later classification by
35   sending charging detail records which at least indirectly indicate whether or not the mobile station was in an LSA cell (and what kind of LSA cell, if they are different charging-wise) when the corresponding event took

place. Such indirect indication means that on the basis of the mobile station's LSA cell list, it is possible to classify the detail items in the CDR into two classes, depending on whether or not the MS was in a special cell.

According to a preferred embodiment of the invention, central-
5 ised charging is supplemented with distributed pre-processing in the support nodes of the packet radio network, preferably in the SGSN nodes. The reason for using the SGSN nodes for charging is as follows. The network element making decisions about handovers must be informed about the mobile station's LSA cells. In a GSM system, such a network element
10 is the Base Station Controller BSC. In 3rd generation (3G) systems, it will probably be called Radio Network Controller RNC. (Later in this application, the term 'BSC' refers commonly to both a BSC and an RNC.) The network element which informs the BSC about the LSA cells is most conveniently the SGSN serving the mobile station MS. Thus the SGSN must
15 be aware of the MS's LSA cells. Preferably, the MS-specific LSA information is included in a modified INSERT SUBSCRIBER DATA (IMSI, GPRS SUBSCRIPTION DATA, SoLSA PARAMETERS) message which the Home Location Register HLR sends to the serving SGSN when the MS initiates a GPRS ATTACH or a ROUTING AREA UPDATE procedure. The serving SGSN
20 can deliver the subscriber-specific SoLSA parameters to the serving BSC e.g. in a modified BSSGP_DL_UNITDATA.REQ message or in a new dedicated BSSGP_SoLSA message. The BSC can take the SoLSA parameters into account in the network-controlled cell reselection, when a BSC-based solution will be used.
25 Because the SGSN must be aware of the MS's LSA cells, some synergy benefits will be achieved by using the SGSN as a pre-processor for charging.

Brief description of the drawings

The invention will be described in more detail by means of pre-
30 ferred embodiments with reference to the appended drawing in which:

Fig. 1 is a block diagram showing some elements of a packet radio network which are essential for describing the invention;

Fig. 2 is a signalling diagram illustrating a preferred embodiment of the invention;
35 Fig. 3 shows a possible interconnection of the network elements responsible for LSA management and charging; and

Figs 4A and 4B schematically illustrate charging detail records.

Detailed description of the invention

A limitation associated with prior art systems for providing special services in a network is that SoLSA is only defined for circuit-switched connections, i.e. GSM and its derivatives. In a dual-mode GSM/GPRS

5 network, the coverage of GSM and GPRS services may be different. Thus the prior art SoLSA provides little or no support for packet-switched connections, e.g. GPRS. A specific problem with the prior art GSM SoLSA is encountered when a dual-mode mobile station with SoLSA active is involved in a GPRS connection. In such a situation, SoLSA support is dis-

10 continued because GPRS cell reselection does not take SoLSA into account. A solution for this problem is disclosed in Co-assigned Finnish patent application FI981130, "Solunvalinta pakettiverkossa", filed 20 May 1998. For convenience, the relevant subject-matter of the '1130 application is repeated here. As shown in Fig. 2, a functioning GSM/GPRS inter-

15 working system can be attained by a method for controlling the operation of a mobile station, the operation comprising camping. The method is summarized as follows. The camping is modellable as a number of states (S1 to S4) with predetermined state transitions (S_{12} - S_{34}) between them, wherein each one of the states corresponds to a set of locally varying

20 features which the mobile station currently supports. The features comprise a first feature indicating whether the mobile station is in circuit-switched mode or packet-switched mode, and a second feature indicating whether or not the mobile station is in localised service area (LSA) mode. For all combinations of the first and second features, there is a corre-

25 sponding state (S1 to S4), and for each one of these states, there are two originating state transitions and two terminating state transitions, each one of the originating state transitions corresponding to a change in the respective feature.

Preferably, the criteria for the state transitions are based on the

30 fact that of the two communications modes, i.e. circuit-switched and packet-switched, one has better coverage. In a combined GSM/GPRS system, GSM typically has better coverage than GPRS. Thus, in situations where there is a possible conflict between a state transition based on GSM criteria and a state transition based on GPRS criteria, it is advanta-

35 geous to use the GPRS criteria to determine whether the mobile station is in SoLSA mode or not. Such a conflict may occur when the mobile station has an activated GPRS context (in Standby or Active state). In such a

situation, the mobile station would not perform state transition T_{12} unless T_{34} is also possible.

The block diagram of Fig. 3 shows a possible interconnection of the network elements responsible for LSA management and charging. Subscriber-specific LSA information can be stored and managed either in the Camel Service Environment CSE or in the Home Location Register HLR. Two types of LSAs can be foreseen, either a truly customised LSA for a small office area and a residential area ("office/home zone"), or a predefined LSA covering large campuses, sections of cities and districts ("city zones"), etc. These two LSAs fulfil different needs. They complement each other and they can be used simultaneously. A SoLSA subscriber can have a home LSA consisting of 1 or 2 cells, an office LSA consisting of 1 to 5 cells and a city LSA with dozens or hundreds of cells. The first two LSAs are preferably tailored on a per-subscriber basis. A truly subscriber-specific LSA can be defined on a cell identity basis and it can be very small, even consisting of only one cell, if necessary. The third LSA could rely on a certain predefined LSA definitions. LSA information can consist of:

- List of cell identities belonging to an LSA (e.g.: Cell Global Identity (MCC+MNC+LAC+CI), MNC+LAC+CI LAC+CI or CI).
- LSA_ID (The LSA ID is a number uniquely assigned to an area in one network. LSA ID can be associated with a Cell Identity list.)
- LSA name (a text string describing an area and/or service, e.g. "Etsi Building").
- LSA indication (a flag to activate/deactivate LSA indication)
- LSA priority (a number value needed to support overlapping LSAs, for example a city zone and office cells in the same area).
- LSA only access (Service outside LSAs is restricted).
- LSA only access indication text (Text to be displayed when out of LSA area).
- Exclusive access (User has exclusive access to a LSA).
- Relevant MSP profile (an LSA may be associated with some MSP profiles).
- Idle/active mode support (preferred cell selection in idle/active mode may be utilised in an LSA).

The network operator can use the Network Management Services NMS to define the subscriber's LSA areas. There can be one com-

mon list of LSA areas for a given subscriber. In this case, there are virtually no GSM/GPRS interworking problems. The subscriber's LSA data should be transferred to the BSC via circuit-switched (CS) and packet-switched (PS) connections, as needed (e.g. during call set-up for CS, and during GPRS Attach and inter-SGSN handover for PS). The LSA list should be broadcast on the BCCH and PBCCH (if allocated).

Alternatively, the LSA areas may be different for CS and PS services. In this case, the HLR has to store two separate LSA lists. However, it is sufficient to store only a single LSA list in the MS's SIM card. If no PBCCH is allocated, both CS and PS LSA lists should be broadcast on the BCCH. If both BCCH and PBCCH are allocated, there are at least two configuration options:

1) CS LSA ids are broadcast on the BCCH only, and PS LSA ids are broadcast on the PBCCH only. In this case, the priorities are applicable only inside CS and PS LSA areas.

2) Both CS and PS LSA ids are broadcast on the BCCH and PBCCH. Such a configuration is simpler than the previous one because the LSA priorities are followed in all situations.

For circuit-switched SoLSA, the BSC needs the subscriber's LSA data for active mode support in the BSC. A corresponding mechanism for packet-switched SoLSA should be implemented because the LSA data is needed for network-controlled cell reselection. The network-controlled cell reselection parameters are broadcast on the Packet Broadcast Control Channel PBCCH, and they are valid for all mobile stations in Ready state in the cell in question. Cell reselection commands can also be sent to an individual MS on a Packet Access Control Channel PACCH, in which case such a command overrides the PBCCH parameters. The SGSN nodes can get these parameters from the HLR e.g. in a modified INSERT SUBSCRIBER DATA message, whose parameters include the subscriber's IMSI, GPRS Subscription data and the SoLSA parameters). The HLR can send this message to the SGSN e.g. in response to a GPRS Attach procedure. The SGSN can deliver the subscriber-specific SoLSA parameters to the BSC serving the MS e.g. in a modified BSSGP_DL_UNITDATA.REQ message or in a new dedicated BSSGP_SoLSA message. The BSC can take the SoLSA parameters into account for the network-controlled cell reselection, if a BSC-based solution is used.

To summarise, the BTS sends to the MS:

- on the BCCH: CS LSA_id list, CS LSA cell reselection parameters, and the cell_id;
- on the PBCCH (if allocated): PS LSA_id list, PS LSA cell reselection
  5   parameters, the cell_id and network-controlled cell reselection parameters;
- on the PACCH: individual cell reselection commands.

In each of these cases, it can be seen that the LSA parameters are needed for supporting the mobility of the mobile station, and for
10 charging its subscriber. Therefore, certain synergy benefits will be achieved by using mobility support elements of the networks also as a pre-processor for charging purposes, as will be described below in more detail.

According to a primary embodiment of the invention, the Base
15 Station Controller BSC currently serving the mobile station MS adds the MS's current cell identity (cell_id) into the data packets it sends to the serving SGSN. Thus the SGSN knows the cell identity of the mobile-originated (MO) packets. When the MS is in Ready mode, the SGSN also knows the cell_id of the MS before it sends mobile-terminated (MT) pack-
20 ets to the MS. Otherwise, the SGSN pages the MS, after which it knows the MS's current cell_id. In conclusion, the SGSN always knows the cell_id of the MS for both MO and MT packets.

There are at least two ways in which the network can correlate the charging-related aspects of data transmission with the cell_id of the
25 cell where the MS has sent or received data. For example, Fig. 4A depicts schematically a set of CDRs, CDR1 to CDR3, such that each CDR includes information from only one tariff zone (in this case, only one LSA). Each CDR includes a header. (For the purposes of this application, the word 'header' has a wide interpretation, in the sense that it comprises eve-
30 rything which is required by the relevant standards but which is not listed as detail items elsewhere in the CDR.) As long as the MS remains in the same LSA, the SGSN keeps open the S-CDR. When the MS moves to a different tariff zone, the previous S-CDR will be closed and a new one will be created. The set of CDRs comprising CDR1 to CDR3 correspond to the
35 scenario of Fig. 1, wherein the MS moves along the path 10 from cell C1 to cell C10. As long as the MS is in LSA1 (i.e. cells C1 to C3), the SGSN keeps CDR1 open and collects charging-related detail items (item11 to

item 13, etc.) CDR1 also shows that all the items in it relate to events in an LSA whose LSA_id is 1 (i.e. LSA1). Similarly, CDR2 includes items relating to events which took place while the MS was in cell C4, which is not in an LSA (at least, to this subscriber) and which does not have an LSA_id.

5   CDR3 includes items relating to events which took place while the MS was in cells C9 and C10, which to this subscriber constitute LSA2 having an LSA_id of 2.

    In CDRs according to reference 4, the LSA_id can be transferred e.g. in a field called "Record extensions", but, preferably, a dedi-

10   cated field should be defined for this purpose.

    Fig. 4B shows a different CDR4, wherein each detail item has the corresponding LSA_id next to it. In this case, the format of the CDR according to reference 4 is definitely not sufficient, because the "Record extensions" field is common to the entire CDR.

15   Figs. 4A and 4B show embodiments wherein the full LSA_id is included in the CDR. For charging purposes, it is sufficient to include only yes/no information, indicating whether or not the MS was in an LSA cell when the relevant event took place.

    According to a secondary embodiment of the invention, the

20   SGSN may not know the MS's SoLSA parameters, or the manufacturer or the operator prefers not to add to the complexity of the SGSN in the manner described in connection with the primary embodiment. In such a case, the format of the S-CDR can be changed so that its detail items (the List of Traffic Data Volumes field) record the cell_id and data volume for every

25   different cell_id. Sorting the cells into LSA cells and non-LSA cells according to the MS's SoLSA parameters can take place in the Charging Gateway or the Billing Centre.

    It is also possible to support SoLSA charging without changing the format of the S-CDR. In this case, the MS's most current cell_id is de-

30   termined at the time when the S-CDR is created, and this cell_id will be used as a basis for charging. The cell where a GPRS ATTACH or a ROUTING AREA UPDATE procedure is performed determines the tariff zone. The changes in the MS's Routing Area are recorded in the M-CDR, and they could also be used for determining the tariff zone. If the LSA borders

35   were also Routing Area borders, no other correlation mechanism would be

needed. However, SoLSA charging based on existing CDRs is considered inflexible.

The description only illustrates preferred embodiments of the invention. The invention is not, however, limited to these examples or the terms used, but it may vary within the scope of the appended claims.

Reference:

1. Co-assigned PCT publication WO98/30056, *"Localised special services in a mobile communications system"*
2. ETSI Draft TS 03.73 v. 0.5.0 (April 1998)
3. ETSI Draft TS 02.43 v. 0.0.0 (July 1998)
4. ETSI Recommendation GSM 12.15, v. 2.0.0 (June 1998).
5. Co-assigned Finnish patent application FI981130, *"Solunvalinta pakettiverkossa"*

All references are incorporated herein by reference.